HBT radii and the geometry of the pion effective source in Au+Au collisions at RHIC

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For the Gaussian pion source, the HBT radii, parameters extracted from the Gaussian fit to the HBT correlation function, correspond to the variances of the particle spatial distributions at freeze-out: $R_i^2 = \mathrm{RMS}^2_{(x_i - V_i t)}$, where V is the pion velocity. In reality, both the correlation function and to a larger extent the particle space-time distributions are far from being Gaussian. R_i's, what do they correspond to in this case? The Gaussian fit to the correlation function mainly yields the value of $\langle q_i^2 \rangle = ((R_i^2)^{-1})/2$, where the average is taken over the function of $C_2(q) - 1$. From the definition of the correlation function it follows that

$$\langle q_i^2 \rangle = \langle \partial^2 S(\Delta r_i)/\partial \Delta r_i^2 |_{\Delta r_i = 0} \rangle,$$

where $S(\Delta r_i)$ is the distribution in the relative distance between particle production points, $r_i \equiv x_i - V_i t$. The second derivative is calculated for a Gaussian fit to the source function.

We apply this technique to the RQMD v2.4 simulated events for Au+Au collisions at RHIC (centrality $b < 3$ fm). The analysis is performed for pions (rapidity region $-0.5 < y < 0.5$) in different p_t bins. Fig.1 shows the spatial distributions used for the evaluation of HBT radii. Note the long non-Gaussian tails which are responsible for the difference in the RMS values and the variances from the Gaussian fit (performed over the region of $\pm$ 1.5 RMS value of the distribution). The difference in the RMS and σ values (Fig. 1, right panel) shows the possible error in calculation of R_i^2 using just the RMS values. In Fig. 2 we compare the results for R^2_{side} evaluated from the fit to the correlation function and the radius parameter from the Gaussian fits to the distribution in Δr_i. The agreement seems to be very good.

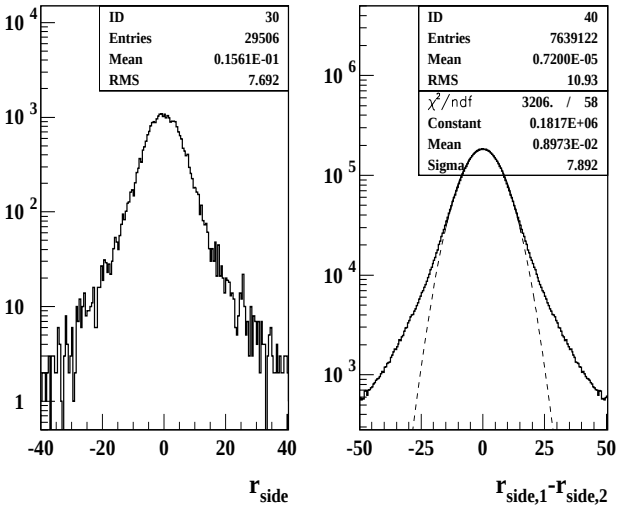

Figure 1: Single particle distribution in r_{side}, the projection of the radius-vector of pion production point on a plane perpendicular to pion transverse momentum (left panel). The distribution in relative distance for pion pairs.

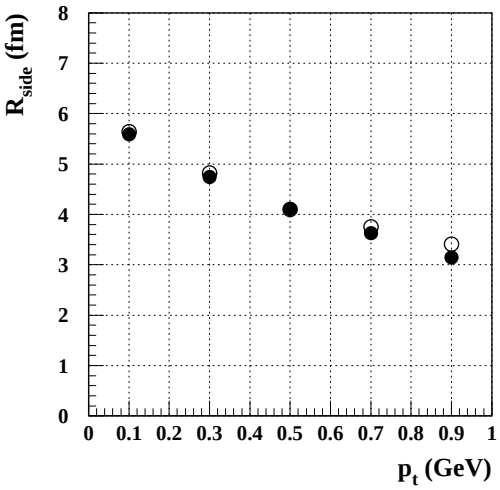

Figure 2: Comparison of the R_{side} HBT parameter evaluated by the fitting of the correlation function (filled circles) and calculated directly from pion spatial distribution at freeze-out.